

**DESIGN, ANALYSIS AND MANUFACTURING OF BRAKE AND
TRANSMISSION SYSTEM FOR ALL TERRAIN VEHICLE**

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Abstract- The study aim is to design and manufacture the transmission and braking system for an ATV vehicle according to the constraints provided in the rulebook of Baja SAE India 2018 for the single seater All-Terrain Vehicle. This project include selection of a suitable transmission and braking system for ATV, according to the given constraints of engine (CC) and brake system configuration in the rule book.

In this project we are design 1- braking system for a Baja SAE vehicle that can produce adequate braking force to stop the vehicle in minimum possible time and distance to meet the competition regulations while being as light weight as possible. 2- transmission system to provide adequate torque, acceleration and speed to overcome tractive effort required for the motion of vehicle. The above systems should also have limit un-sprung weight to reduce overall weight of the vehicle which helps in improve maneuverability and acceleration of the vehicle. The factors such as safety, durability, appearance, design, performance, and ultimate cost also plays an important role in the design and manufacturing process. Design, Analysis and manufacturing is done according to Design consideration, mathematical data, static and dynamic analysis of transmission and braking system. In this paper Design and analysis of Brake Disc, Gearbox shaft and Gear, Hub and Stub is done. The structural model is prepared in CREO software and analysis of the Disc is accomplished in ANSYS software.

Keywords– Braking System, Disc Brake, Transmission system, CVT, ANSYS, ATV, SAE BAJA

I. INTRODUCTION

ATV means all terrain vehicle which is specially designed for off roads driving. ATV is designed for very rough terrain, jumps, endurance. The design process of this single-person vehicle is iterative and based on several engineering and reverse engineering processes.

A braking system is one which stops the motion of a vehicle by converting its kinetic energy into heat energy. There are basically three types of brakes used in automobiles:

1. Mechanical Brakes
2. Hydraulic Brakes
3. Air and other types of Brakes

A choice has to be made whether to choose disc brakes or drum brakes. After studying the advantages and disadvantages of both, Hydraulic Disc brakes have been selected for the ATV for the following reasons:

- i. Disc is directly in contact with cooling air, thus no separate cooling system for brakes.
- ii. Brake pads undergo uniform wear; this is beneficial since ATV requires frequent use of brakes.
- iii. No loss of braking efficiency due to expansion/contraction of Disc.
- iv. Total weight of disc-brake arrangement is less than drum-brake arrangement.
- v. Designing of disc brake is simpler.
- vi. Less space is required as compared to drum brake.

A disc brake is a wheel brake which slows rotation of the wheel by the friction caused by pushing brake pads against a brake disc with a set of calipers. The brake disc (or rotor in American English) is usually made of cast iron, Stainless steel but may in some cases be made of composites such as reinforced carbon-carbon or ceramic matrix composites. This is connected to the wheel and/or the axle. To stop the wheel, friction material in the form of brake pads, mounted on a device called a brake caliper, is forced mechanically, hydraulically, pneumatically or electromagnetically against both sides of the disc. Friction causes the disc and attached wheel to slow or stop. Brakes convert motion to heat, and if the brakes get too hot, they become less effective, a phenomenon known as brake fade.

The performance aspect of the vehicle is measured from the accomplishments of the vehicle in 5 dynamic events: the Acceleration, Hill Climb, Maneuverability, Rock Crawl, and Endurance challenges. The Drive Train Team is responsible for

the design of the engine through to the wheels. This will include the engine, transmission, and any power transmitting shafts. The engine is a constraint in our design, as SAE requires the use of a Briggs & Stratton Model 19 engine. This specific model of engine proposes a challenge due to its maximum power output being 10 horsepower. We set a goal of placing in the top ten in two specific events: Acceleration, and Hill Climb. These events were chosen because the overall performance in these events depends greatly on the design and execution of the transmission design. The set performance goals to achieve this objective are to complete a 100 foot distance in 4 seconds from a complete stop, and for the vehicle to be able to drive up a hill of about 60 degrees.

The main objective of the transmission is to provide to the enough torque to the wheels from engine to the wheels. The enough torque means required to pull the driving wheels against the road loads. Road loads include rolling resistance (RR) resistance / air resistance (AR) and grade (GR). To choose the transmission capable of producing enough torque to propel the Baja vehicle, it is necessary to determine the total tractive effort (TTE) requirement of the vehicle^[6].

II. OBJECTIVES OF BRAKE SYSTEM

- i. Design a braking system that can produce more than adequate braking force to meet Baja SAE competition regulations while being as light weight as possible.
- ii. The system should also limit un-sprung weight to help improve maneuverability.
- iii. This needs to last through testing and the competition, including 4 hour endurance.
- iv. The system should be able to stop all four wheels at a time.
- v. Reduce the required driver input.
- vi. Reduce the time and tools required to adjust bias in the system.
- vii. Reduce weight in the overall system.
- viii. Increased reliability.
- ix. Improved performance.

III. MAJOR COMPONENTS OF BRAKING SYSTEM

3.1 Brake Pedal

The main premise of a hydraulic braking system is very simple: driver force applied at the brake pedal is transferred hydraulically to locations at the wheels or axle to reduce rotational speed and therefore vehicle speed. This simple task is completed using the short list of components given in the previous section.

Beginning the process from the driver's effort to push one end of the brake pedal, the movement of the pedal actuates the plunge rod that is attached to the other end of the pedal. This plunger rod moves a plunger inside the master cylinder and decreases the volume within the cylinder, increasing the pressure of the fluid inside^[2].

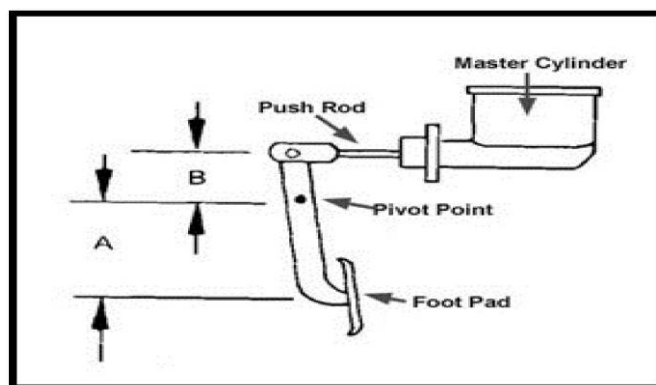


Figure1.BasicPedalDiagram

3.2 Master Cylinder

The brake system is with a single tandem cylinder. Although there is only one cylinder, it houses two separate chambers, each with their own reservoir inlet and circuit outlet, that are pressurized by the same plunge rod.

The major decision that has to be made when selection a master cylinder is whether to use separate cylinders for the front and the rear circuits or to use one tandem cylinder that serves both. The Baja SAE Rules document states that the front and rear circuits must be completely independent of each other so that if a leak should occur in one circuit, the other one will remain

in working order. Both types of systems fulfil this requirement, but the pros and cons of each have to be considered before making a selection. So we selected Tandem Master Cylinder of Maruti 800^[4].



Figure2. Tandem Master Cylinder of Maruti 800 (BOSCH)

3.3 Brake disc

The disc brake is a wheel brake which slows rotation of the wheel by the friction caused by pushing brake pads against a brake disc with a set of callipers. The brake disc (or rotor in American English) is usually made of cast iron or stainless steel, but may in some cases be made of composites such as reinforced carbon– carbon or ceramic matrix composites. This is connected to the wheel and/or the axle. To stop the wheel, friction material in the form of brake pads, mounted on a device called a brake calliper, is forced mechanically, hydraulically, pneumatically or electromagnetically against both sides of the disc. Friction causes the disc and attached wheel to slow or stop. Brakes convert motion to heat, and if the brakes get too hot, they become less effective, a phenomenon known as brake fade^[1].



Figure3. Brake Disc

3.3.1 Selection of Disc Material

Table1. Material comparison Brake Disc material

Material Properties	Cast Iron	Stainless Steel (SUS 304)
Density	7100 (kg/m ³)	8000 (kg/m ³)
Young Modulus	125 (Gpa)	190 (GPa)
Tensile Strength	414 (Mpa)	520 (Mpa)
Yield Strength	276 (Mpa)	240 (Mpa)
Poisson's ratio	0.25	0.27-0.30
Coefficient of thermal expansion	5.8 (0-212 ⁰ C)	18.4 (0-538 ⁰ C)
Thermal Conductivity (W/m.K) at 100 ⁰ C	54	16.2
Specific Heat 0-100 ⁰ C (J/kg.K)	586	500
Brinell Hardness (HB)	180	88

SUS 304 is chromium-nickel content and low carbon, is the most versatile and widely used of the austenitic alloy. It contains 18% chromium and 8% nickel. SUS 304 proves to be oxidation resistant to oxidation, corrosion and durability. It provides ease of Fabrication and cleaning. It is cost effective than other materials. The weight of SUS 304 is less than cast iron. It is very robust and tolerant to almost all Brake pads. It is highly resistant to wear, it doesn't shatter and it resist heat very well.

Cast iron possesses carbon in the form of graphite flakes in a matrix that comprises of pearlite, ferrite or a combination of the two. Gray Cast Iron is a material that is most extensively used material in engineering applications. Gray Cast iron has high thermal conductivity. But Cast Iron is heavy and it also rusts. It also has low tensile strength.

So considering strength, weight cost and availability we selected SUS 304 as disc material.

3.3.2 Brake Disc Specification

Outer Diameter of Disc = 160 mm

Disc Thickness = 4 mm

Disc Material = SUS304

SUS 304 Material Properties:

Density = 8000 (kg/m³)

Young Modulus = 190 (GPa)

Tensile Strength = 520 (Mpa)

Yield Strength = 240 (Mpa)

Poisson's ratio = 0.27-0.30

Coefficient of thermal expansion = 18.4 (0-538⁰C)

SUS 304 Material Composition:

Fe=bal.

C=0.06 %

Cr=18.30%

Ni=8.30%

Mn=1.57%

Si=0.60%

P=0.03%

3.3.3 Analysis of Brake Disc

Ansys is one of the useful software for design analysis in mechanical engineering. This software is based on the Finite Element Method (FEM) to simulate the working conditions of your designs and predict their behaviour. FEM requires the solution of larges systems of equations. Powered by fast solvers, Ansys makes it possible for designers to quickly check the integrity of their designs and search for the optimum solution.

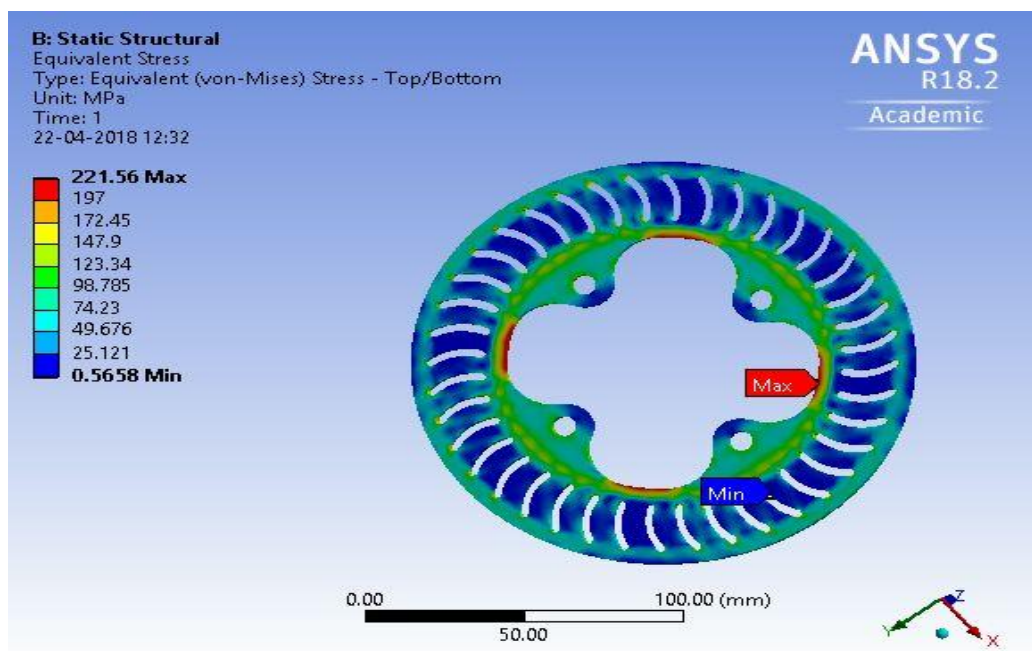


Figure4. Stress on Brake Disc

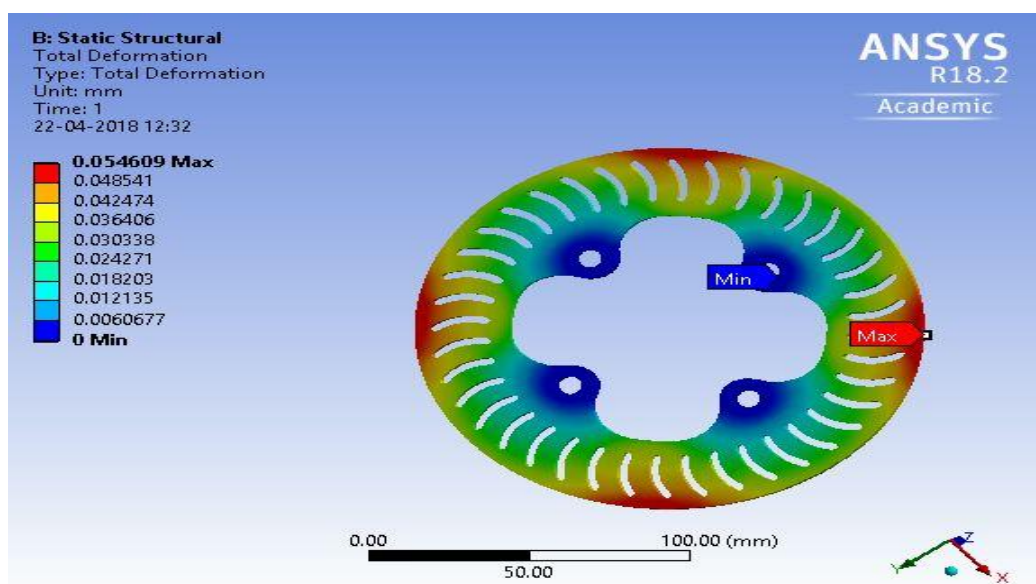


Figure5. Total Deformation on Brake Disc

Result:

Table2. Result of Analysis of Brake Disc

	Minimum value	Maximum Value
Total deformation (mm)	0	0.054609
Stress (Mpa)	0.5658	221.56

3.4 Selection of Caliper

In a Disc-Braking system the car's wheels are attached to metal discs, or rotors, that spin along with the wheels. The job of the caliper is to slow the car's wheels by creating friction with the rotors. It is a device which Holds pads and squeezes them against rotor. The selection of the front and rear calipers were made primarily based on mounting ability. Following are our design considerations

- i. It should be compact in size so that appropriate mountings can be made.
- ii. According to braking force required bore diameter is selected^[7].



Figure6. Piaggio Vespa Caliper

3.5 Selection of Brake fluid

Selection of Brake Fluid is done by considering the characteristics of Brake fluid. We selected DOT 4 as a Brake Fluid. The following are the reasons for selecting DOT 4 as a Brake Fluid.

- i. Viscosity of DOT 4 Brake Fluid is more than any other Brake Fluid.
- ii. DOT 4 Brake Fluid absorbs less water than DOT 3 Brake Fluid.
- iii. It maintains its Fluidity at high temperature^[8].

IV. SPECIFICATIONS FOR BRAKES

- i. The pedal is with a pedal ratio of 6:1 for maximum leverage.
- ii. Armoured steel braided brake lines run through the length of the car and flexible rubber lines at the A-arms in the rear for suspension travel. These were chosen due to their flexibility and their strength and ability to maintain high line pressure values.
- iii. The reliability of our braking system is improved by having separate disk and calipers on each wheel. The front and rear brakes consists of self-designed discs of 160mm OD, right and left caliper from piaggiovespa.
- iv. The material of disc is SUS304.
- v. Brake oil to be used is DOT 4.

V. CALCULATIONS FOR BRAKING SYSTEM

1) Deceleration $= \mu * g$

For ATV μ is generally considered as 0.6

$$= 0.6 * 9.81$$

$$= 5.886 \text{ m/s}^2$$

2) Total breaking force $= mag$

$$= 180 * 0.6 * 9.81$$

= 1059.48 N
 3) Pedal Force Required = Total braking force / Pedal ratio
 = 1059.48 / 6
 = 176.58 N
 4) Stopping Distance = $V^2 / 2a$
 = $12.52^2 / (2 * 0.6 * 9.81)$
 = 13.2730 m.
 5) Stopping time = $2sU + v$
 = $2 * 13.27 / 12.5 + 0$ = 2.12 sec.
 6) Pedal Travel = $0.9 * w * \text{pedal force}$
 = $0.9 * 180 * 9.81 * 0.6 / 176.58$
 = 5.4 cm.
 7) Weight Transfer = $m * a * CG / \text{wheelbase}$
 = $180 * 0.588 * 38.8660$
 = 68.54 N
 Weight Transfer = 38%

VI. SELECTION OF TRANSMISSION SYSTEM

For baja buggy there is two options manual or automatic transmission system. After studying advantages and disadvantages of both, Automatic transmission systems have been selected for an ATV for following reasons:

- i. Less Driver fatigue.
- ii. Better fuel efficiency.
- iii. No loss of torque transmission from engine to the driving wheels during gearshifts.
- iv. Faster acceleration and increased driving comfort.
- v. It contributes to safer driving because the concentration of the driver is not disturbed by the need to change gear also by both hands can remain on the steering wheel.
- vi. Time consume due to gear shift is neglected in automatic transmission.

VII. MAJOR COMPONENTS OF TRANSMISSION SYSTEM

7.1 Continuous Variable Transmission (CVT)

The continuous variable transmission (CVT) is plays a most important part in the performance of the vehicle. Thus, it not only save the weight of other components but also provide the smooth ride by allowing driver to shift the infinite number of reduction between the low gear and high gear. Low gear is same as the first gear and high gear corresponds to four gear box. The selection of CVT is also due to the fact that the shift in speed and acceleration is continuous with CVT which is in step with gear box. The CVT also allow the engine to run at peak power which is very much desirable for the better performance of the vehicle and good fuel economy of the engine.

C.V tech CVT specifications

- i. High ratio- 0.43
- ii. Low ratio- 3
- iii. Efficiency- 86%

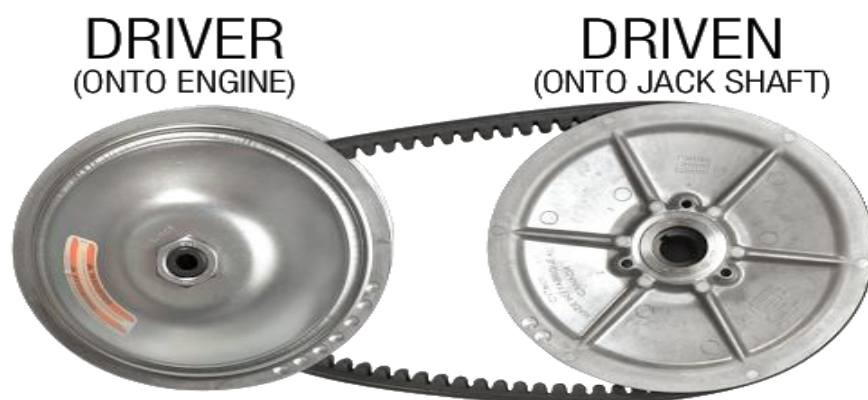


Figure7. CV Tech CVT

7.2 Gearbox

Gearbox is a mechanical device which is used for transmitting motion or power from Engine to the road wheels by changing the speed or torque or by changing the orientation of drive. We used 2 Stage Reduction Gearbox.

Functions of Gearbox: The Engine produces torque or tractive effort over a limited engine speed. But an automobile is driven under different conditions requiring large variation in torque at road wheels. The main function of Gearbox is to provide a mean to vary the torque ratio between the engine and the road wheels as and when required. It also required proper arrangement for mounting of rollcage and for CV shaft^[10].

7.2.1 Analysis of gear

1) Mechanical Properties of 20 Mncr5:

Density = 7.7-8.03 ($\times 1000 \text{ kg/m}^3$),

Elastic Modulus = 190-210 (GPa)

Tensile Strength = 1000-1300 (Mpa)

Yield Strength = 1034 (Mpa)

Poisson's ratio = 0.27-0.30

Hardness = 335 (HB)

Elongation = 15 (%)

2) Chemical Properties of 20 Mncr5:

C = 0.17-0.22, Si = 0.10-0.35, S = 0.35, P = 0.35, Mn = 1.10-1.40, Cr = 1.00-1.30

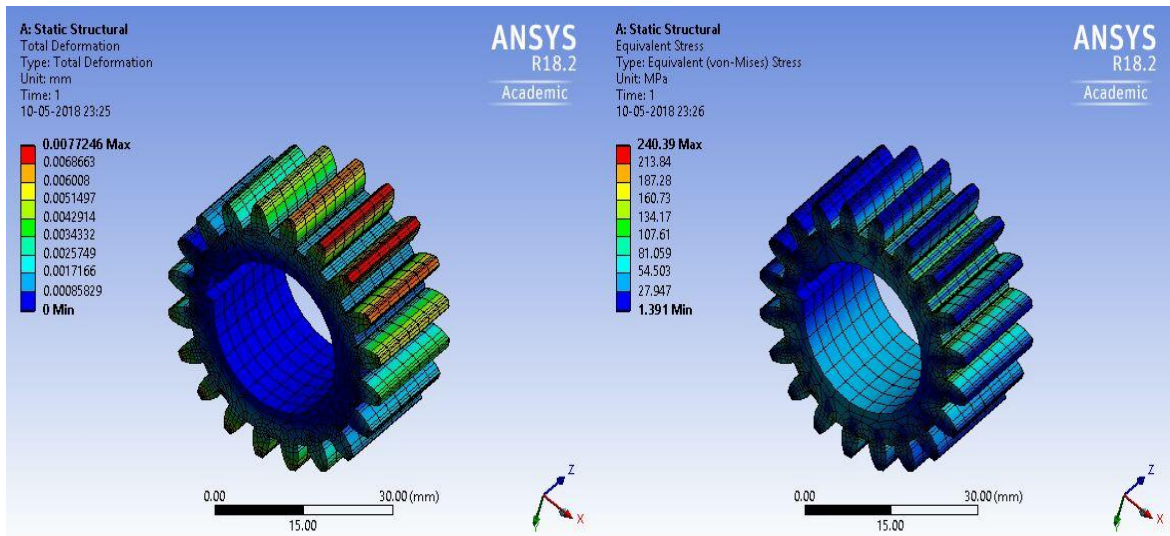


Figure8. Analysis of Pinion (Stress and Deformation)

Result of Pinion:

Table3. Result of Analysis of Pinion

	Minimum value	Maximum Value
Total deformation (mm)	0	0.0077246
Stress (Mpa)	1.391	240.39

7.2.2 Analysis of shaft

1) Mechanical Properties of 20 Mncr5:

Density = 7.7-8.03 ($\times 1000 \text{ kg/m}^3$),

Elastic Modulus = 190-210 (GPa)

Tensile Strength = 1000-1300 (Mpa)

Yield Strength = 1034 (Mpa)

Poisson's ratio = 0.27-0.30

Hardness = 335 (HB)

Elongation = 15 (%)

2) Chemical Properties of 20 Mncr5:

C = 0.17-0.22, Si = 0.10-0.35, S = 0.35, P = 0.35, Mn = 1.10-1.40, Cr = 1.00-1.30

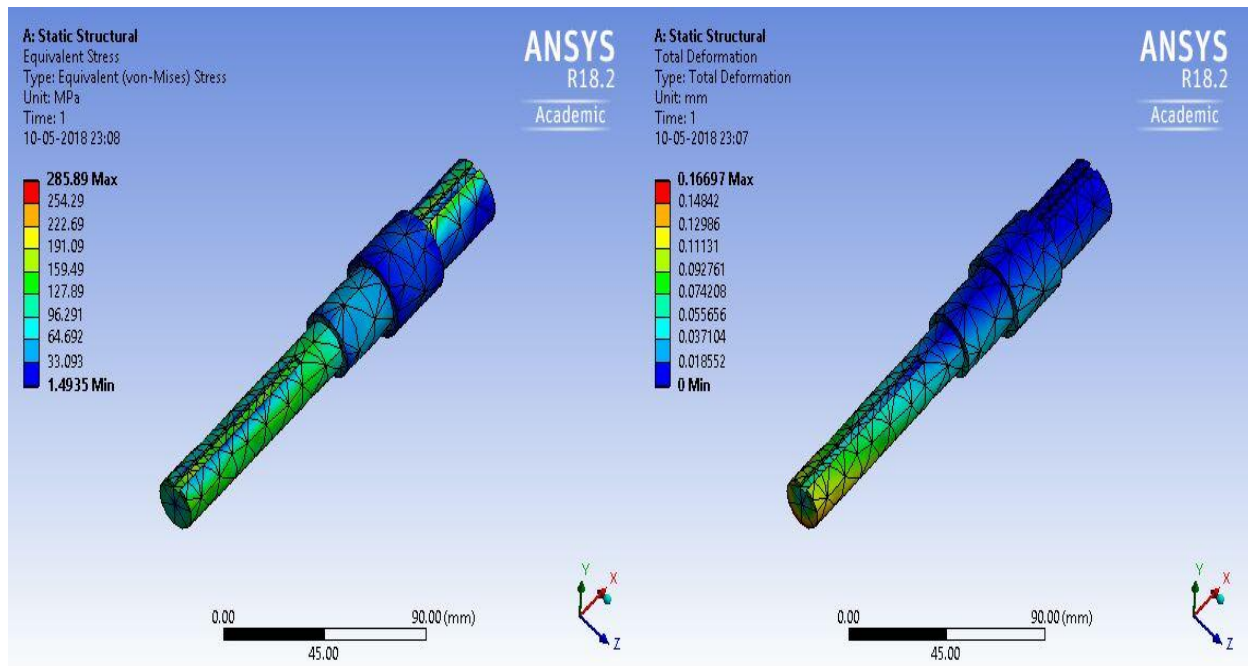


Figure9. Analysis of Shaft (Deformation)

Result of Shaft:

Table4. Result of Analysis of Shaft

	Minimum value	Maximum Value
Total deformation (mm)	0	0.16697
Stress (Mpa)	1.4935	285.89

7.3Design of Hub

7.3.1 Selection of Hub Material

Table5.Material Comparison between Aluminium 7075T6 and EN8

Properties	Aluminium 7075T6	EN8
Poissons ratio	0.33	0.27
Elongation	11%	16%
Hardness	150 HB	201-255 HB
Tensile Strength	572 Mpa	700-850 Mpa
Yield Strength	503 Mpa	465 Mpa

7075T6 is an aluminium alloy with Zinc as the primary alloying element. It is strong, with strength comparable to many steels, and has good fatigue strength and average machinability. It has lower resistance to corrosion than many other aluminium alloys, but has significantly better corrosion resistance. Zinc and Copper mix makes 7075-T6 as hard as many steels, but in a lighter weight aluminium. It has high cost than EN8.

EN8 is a medium strength carbon steel having good tensile strength. It is readily machinable and heat treatable. But it is heavier than Aluminium 7075-T6

So, we selected Aluminium 7075-T6 as our hub material.

7.3.2 Specification for Hub

Wheel bolt PCD = 110mm

Disc bolt PCD = 80mm

Thickness of hub (Front) = 45 mm

Thickness of hub (Rear) = 65 mm

7.3.3 Analysis of Hub

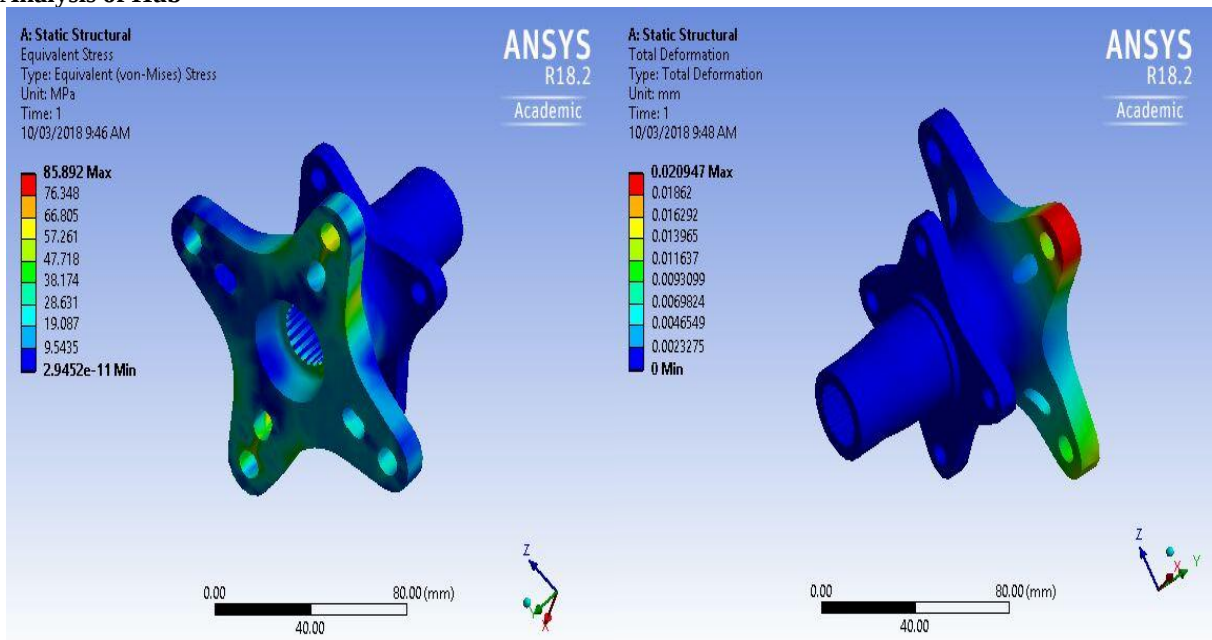


Figure10. Analysis of Rear Hub (Stress and Deformation)

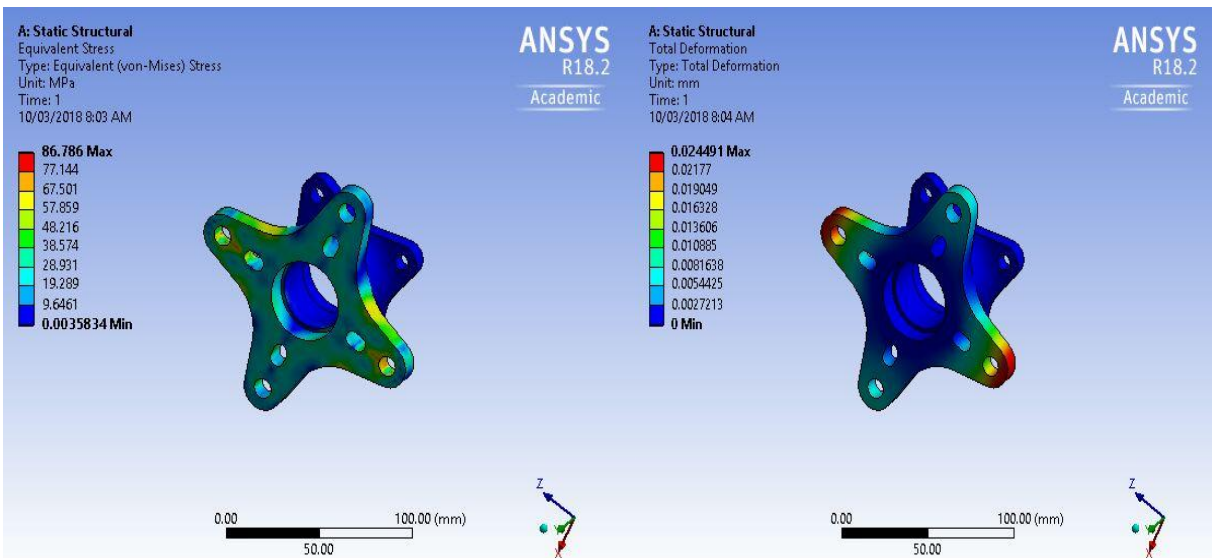


Figure11. Analysis of Front Hub (Stress and Deformation)

Result:
For Front Hub

Table6. Result of Analysis of Front Hub

	Minimum value	Maximum Value
Total deformation	0	0.024491
Stress	0.0035834	86.786

For Rear Hub

Table7. Result of Analysis of Rear Hub

	Minimum value	Maximum Value
Total deformation	0	0.020947
Stress	2.9492×10^{-11}	85.892

7.4 Design of Stub

7.4.1 Selection of Material

Table8. Material Comparison between EN24 and EN8

Properties	EN 24	EN 8
Tensile Strength	850-1000 Mpa	700-850 Mpa
Yield Strength	680Mpa	465 Mpa
Hardness	300	201-255 HB
Elongation	13%	16%
Impact KCV J	50	28

EN 24steel is a popular grade of through-hardening steel alloy steel due to its excellent machinability. It has high tensile strength properties. It is used in the components subjected to high stress and with a large cross section.

EN8 is a medium strength carbon steel having good tensile strength. It is readily machinable and heat treatable.

We selected EN 24 as our Stub Material because of its high tensile strength.

7.4.2 Analysis of Stub

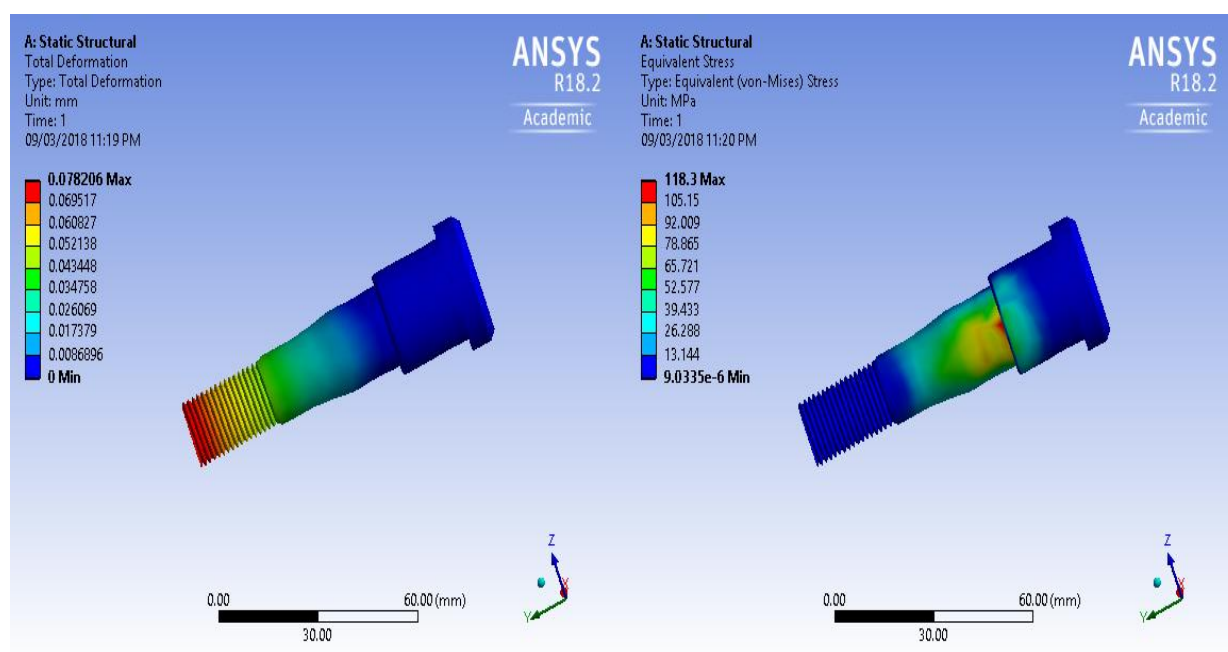


Figure12. Analysis of Stub (Deformation and Stress)

Result:

Table9. Result of Analysis of Stub

	Minimum value	Maximum Value
Total deformation	0	0.078206
Stress	9.0335e ⁻⁶	118.3

7.5 Tyres And Rims

Traction is one of the most important aspects of both steering and getting the power to the ground. The ideal tyre has low weight and low internal forces. In addition, it must have strong traction on various surfaces and be capable of providing power while in puddles. Following are the main parameters in the selection of tyres.

1. Supports weight
2. Transmit vehicles propulsion.
3. Soften impacts from roads.

7.5.1 Selection of Tyre

Tubeless tyre of DURO (22*7*10)is selected-

- i. Tubeless tyre is an advanced version of a conventional tubed tyre.
- ii. The basic differences being that tubeless tyre do not need a separate inner tube.
- iii. The tyres of this type have a special air retaining bead arrangement.
- iv. The tyre is directly mounted on the rim and retains the air.

Keeping in mind all the above mentioned aspects we studied about the various types of tires available in market and decided to use 2-Ply Duro rating tyres, tubeless tyres and that have got specific tread pattern so as to provide a very strong and firm grip on all kinds of surfaces as well as sturdy enough to absorb various bumps and depressions on track. After going through the engine, transmission and some basic torque and angular velocity calculations we have finalized the diameter of front & rear tires to 22 inches which would help us to transmit maximum power. This calculation is also in according to the requirements of Acceleration, Hill climb, Maneuverability and Endurance events^[11].

7.5.2 Rims

- i. The rim is designed in a well pattern to carry the tyre and tube assembly.
- ii. The well construction enables removal/assembly of tyre on the rim of the wheel.
- iii. The seat of the rim where the tyre rests, a taper of 5 to 15 degrees is provided on the internal surface.
- iv. The taper of rim enables a wedges fit of the tyre beads on the rim when inflated.

Selection of rims:

The Rims are made up of Aluminium 6061 to minimize unsprung weight. By reducing the width of the rim the inertia will be directly decreased and subsequently this will also reduce the overall weight. The diameter of all four rims will be 10 inches^[10].



Figure13.Duro Tyres

7.6 CV Shafts

CV shafts consist of CV joints which enables the shaft to transmit constant power at a constant rotational speed at different angles. CV joints provide allowance of angle. We have various types of cv joints with different allowance.



Figure14.CV Shaft of TATA NANO

VIII. CALCULATION OF TRANSMISSION SYSTEM

8.1 Available data

Table10. Parameters for Transmission system

Sr. No	Parameters	Values
1	Gross weight of vehicle	2452.5N
2	Tyre Static radius	0.2921m
3	Tyre dynamic rolling radius	0.283337m
4	Frontal facing area of vehicle	1.0119m ²
5	Coefficient of friction	0.65 (dry road)
6	Coefficient of rolling resistance	0.05 dry road)

8.2 CVT Specification

C.V tech CVT

High ratio- 0.43

Low ratio- 3

Efficiency- 86%

8.3 Engine Specification

Engine: Briggs & Stratton 10HP OHV intake engine

Ideal RPM- 1800

Maximum RPM- 3800

Maximum engine torque- 18.6N-m at 2400 RPM

8.4 Transmission parameters

i. Total tractive effort (TTE)

$$TTE = RR + AR + GR$$

Where,

$$RR \text{ (rolling resistance)} = GVW * fr$$

GVW= Gross weight of vehicle

fr= surface friction

$$AR \text{ (Aerodynamics resistance)} = \frac{1}{2} * \rho * v^2 * A * Cd$$

Where,

$$\rho = \text{Air density (1.122 Kg/m}^3\text{)}$$

v = Velocity of vehicle m/s

A= Frontal facing area of vehicle

Cd= Aerodynamic coefficient (0.44)

$$GR \text{ (Grade resistance)} = GVW * \sin \alpha$$

Where,

α = slope inclined angle w.r.t horizontal

ii. Tw (Torque at driving wheels)

$$Tw = Te * ig_{low} * h_{transmission}$$

Where,

ig_{low} = overall reduction ratio at particular RPM

$$\begin{aligned} \eta_{\text{Transmission}} &= \eta_{\text{gear pair}} * \eta_{\text{CVT}} * \eta_{\text{CV joints}} \\ &= 0.97^2 * 0.86 * 0.98^2 \\ &= 0.793 \\ &= 79.3\% \end{aligned}$$

iii. Acceleration(a)

$$F = Ma \quad \text{therefore } a = F/M$$

Where,

M = Total mass of vehicle in Kg

F = Surplus force available at driving wheels, N

$$F = (F_w - T_{TE})$$

$$F_w = \text{Pull at driving wheels} = T_w / \text{Dynamic rolling radius of tyre}$$

iv. CVT Ratios

Minimum ratio = 3 at 1900 RPM of engine

Maximum ratio = 0.43 at 3700 RPM of engine

CVT ratio at 2400 RPM of engine

By interpolation

$$\begin{aligned} X &= 3 + \frac{(2400 - 1900)}{(3700 - 1900)} * (0.43 - 3) \\ &= 2.2861 \end{aligned}$$

Similarly at various RPM of engine the CVT ratios are as follows

Table11. Various RPM and CVT Ratios

Engine RPM	2400	2600	2800	3000	3200	3400	3600
CVT ratios	2.2861	2	1.715	1.4294	1.1438	0.8583	0.5727

v. Reduction gear box ratio

Engine maximum output RPM = 3750

CVT maximum output RPM = 8720.93

CVT maximum output RPM with CVT efficiency (86%) = 7500

Wheel maximum speed = 60Km/h = 16.6666m/s

Wheel Maximum RPM (N)

$$V = r * \omega$$

Where,

$$r = 0.28337\text{m}, \omega = \frac{2 * \pi * N}{60}$$

Therefore N = 561.7160 RPM

N = 588.23 RPM (considering CV joints efficiency)

$$\text{Reduction gear box ratio (Ri)} = \frac{\text{CVT output RPM}}{\text{Gear box output RPM}}$$

$$= 12.7501$$

$$= 11.9965 \text{ (considering gear pair efficiency)}$$

Taking standard value (Ri)=12

vi. Calculations

At 2400 RPM of engine

$$RR = GVW * f_r$$

$$= 2452.5 * 0.05$$

$$RR = 122.625\text{N}$$

$$AR = \frac{1}{2} * \rho * v^2 * A * C_d$$

$$= \frac{1}{2} * 1.122 * 1.9965^2 * 1.0119 * 0.44$$

$$= 0.9956\text{N}$$

T_w (Torque at driving wheels)

$$T_w = T_e * \eta_{\text{gear pair}} * \eta_{\text{transmission}}$$

$$= 18.6 * 2.2861 * 12 * 0.793$$

$$= 396.53\text{ N}$$

$$F_w = T_w / \text{Dynamic rolling radius of tyre}$$

$$= 396.53 / 0.283337$$

$$= 1399.70\text{ N}$$

$$F = (F_w - TTE) = (F_w - RR - AR - GR)$$

$$= 1399.70 - 122.625 - 0.9956 \dots \dots \dots (GR = 0 \text{ at flat road})$$

$$= 1276.08 \text{ N}$$

Acceleration (a)

$$F = Ma \quad \text{therefore } a = F/M$$

$$= 1276.08/250$$

$$= 5.10432 \text{ m/s}^2$$

Similarly, following values are obtained at different engine RPM

Table12. Values obtained at different engine RPM

Sr. No	Engie RPM	CVT ratio	Te N	Tw N	AR N	V m/s	Fw N	F N	A m/s ²
1	2400	2.2861	16.6	396.53	0.9953	1.9956	1399.7	1276.08	5.104
2	2600	2	18.66	349.315	1.5018	2.4524	1232.86	1108.73	4.435
3	2800	1.715	18.6	298.5746	2.4074	3.1050	1053.78	928.74	3.715
4	3000	1.4294	18.45	246.8459	3.9782	3.9915	871.21	744.60	2.978
5	3200	1.1438	18.15	194.3133	7.069	5.3207	685.80	556.115	2.224
6	3400	0.8583	17.9	143.8030	14.571	7.6392	507.53	370.333	1.481
7	3600	0.5727	17.5	93.8183	36.885	12.155	331.10	171.589	0.686

CONCLUSION

A study was made on the transmission and braking requirements were calculated. On the basis of these requirements and results, a detailed market study was carried out for suitable materials, components and parts were selected. All these components were design for the fabrication process of the vehicle.

We have designed the reduction gearbox, Hub, Stub and Brake disc and then followed by analysis of the system. The stipulated objectives namely Increase power transmission efficiency, meet all the gear ratio requirements, decrease system weight for transmission system. Also Improve performance, reduce weight in the overall system, improve maneuverability for Braking system have been achieved. Overall Designing and Manufacturing of Transmission and Braking system according to required objectives for better performance of an All-Terrain Vehicle.

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